A SEARCH FOR THE LOST IDCSP CONSTELLATION

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? IDCSP Constellation Provides Unique Challenge ? Family of Known US Spacecraft ? Distinctive Orbital Characteristics ? At Limit of Current Capabilities ? Recovery Will Provide Measure of New Sensor Performance

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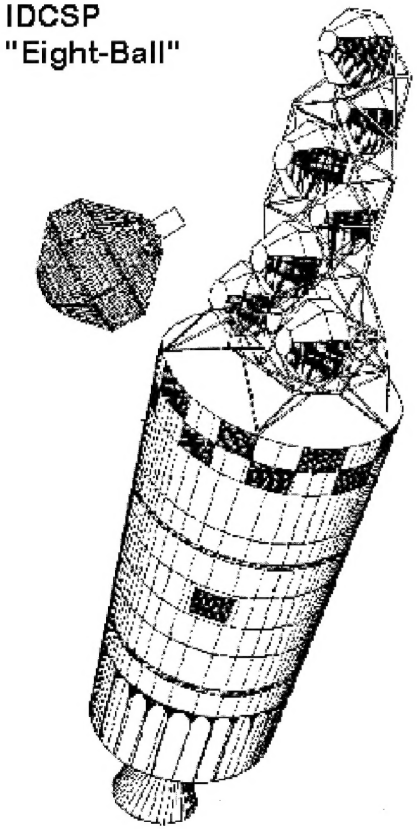
IDCSP: A "Lost" Constellation

- Initial Defense Communication Satellite Program
  - 4 Launches Between 1966 and 1968
  - 34 Objects Placed Into Sub-Geosynchronous Orbits
    - 27 IDCSP Spacecraft
    - 3 Piggyback Satellites
    - 4 Transtages
- IDCSP Spacecraft Infrequently Tracked
  - Small, Faint Payloads
  - Occasional Optical and Radar Detections
  - Track Frequency Less Than "Lost" Criteria
  - Element Sets Periodically Propagated to New Epoch
  - Transtages and Piggyback Payloads Better Maintained
  - Possible Mistagging

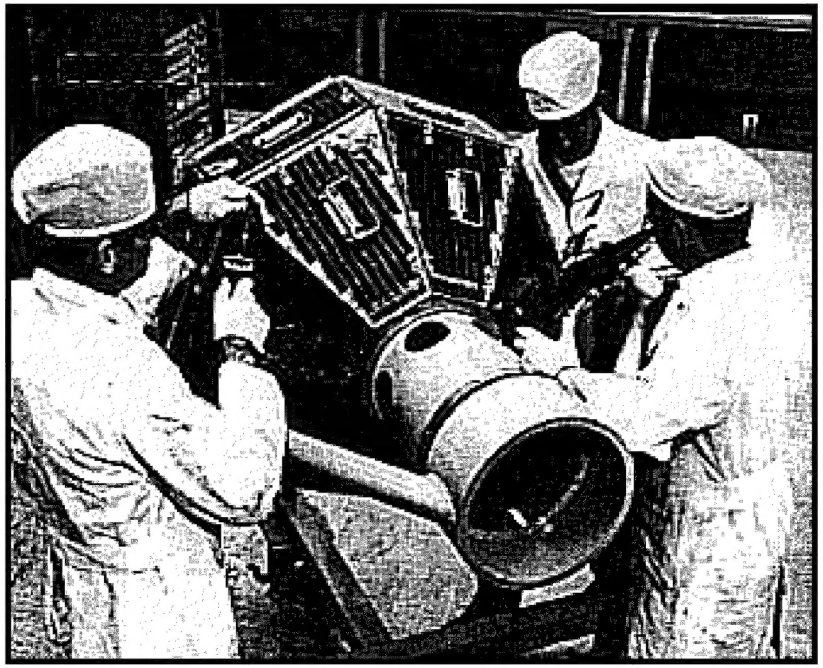
Initial Defense Communications System Program (IDCSP)



- **US Military Constellation**
  - 19-month Development
  - Contractor: Philco-Ford
  - Viet Nam Theater Comm
- **Four Launches 1966-68**
  - "8" Spacecraft per Launch
  - 27 IDCSPs, 3 Other S/C, and 4 Transtages
  - One Failed Launch, Aug '66
- **Sub-Geosynchronous Orbits**
  - 22.2-hr Period (33,760-km)
  - 30° / day West to East Drift
  - 1° to 12° Initial Inclinations

IDCSP Spacecraft

- **Small Payloads**
  - 45-km (100#) Mass
  - ~0.8-m (32") Diameter
  - 26-Sided Polygons
  - 24 Sides Solar Arrays
  - One X-Band Transponder with Horn Antenna
  - Telemetry Antenna on top
  - Spin Nozzles on Equator
- **Faint Objects**
  - Nominal 17th Magnitude
  - Expect Solar Panel Flashes



IDCSP Launch 16 Jun 66

Int Desgn 1966-053	Number	Name	El Set Age (yrs) as of 15 July 99
A	2207	GGTS	4.10
B	2215	IDCSP 1	1.94
C	2216	IDCSP 2	4.10
D	2217	IDCSP 3	4.10
E	2218	IDCSP 4	4.10
F	2219	IDCSP 5	4.10
G	2220	IDCSP 6	4.10
H	2221	Transtage 11	0.01

IDCSP Launch 18 Jan 67

Int Desgn 1967-003	Number	Name	El Set Age (yrs) as of 15 July 99
A	2645	IDCSP 08	4.10
B	2649	IDCSP 09	4.10
C	2650	IDCSP 10	4.10
D	2651	IDCSP 11	4.10
E	2652	IDCSP 12	4.10
F	2653	IDCSP 13	5.50
G	2654	IDCSP 14	4.10
H	2655	IDCSP 15	0.02
J	2655	Transtage 13	3.99

IDCSP Launch 1 Jul 67

Int Desgn 1967-066	Number	Name	El Set Age (yrs) as of 15 July 99
A	2862	IDCSP 16	0.00
B	2863	IDCSP 17	1.47
C	2864	IDCSP 18	1.65
D	2865	IDCSP 19 (DATS)	1.23
E	2866	LES 5	0.01
F	2867	DODGE	0.01
G	2868	Transtage 14	0.01

IDCSP Launch 13 Jun 68

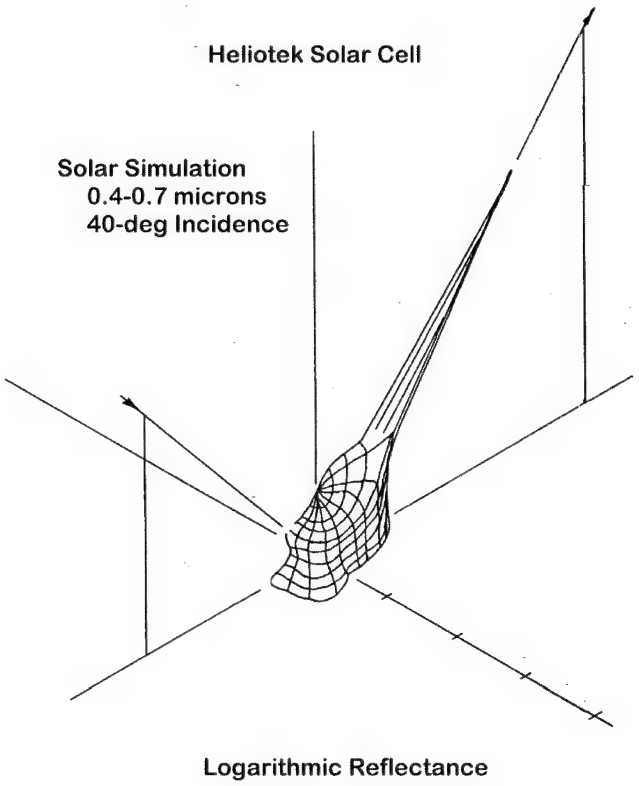
Int Desgn 1968-050	Number	Name	El Set Age (yrs) as of 15 July 99
A	3284	IDCSP 20	1.10
B	3285	IDCSP 21	4.10
C	3286	IDCSP 22	4.10
D	3287	IDCSP 23	4.10
E	3288	IDCSP 24	4.10
F	3289	IDCSP 25	2.18
G	3290	IDCSP 26	4.10
H	3291	IDCSP 27	4.10
J	3292	Transtage 16	0.00

Attempting Optical Recovery of the IDCSP Constellation

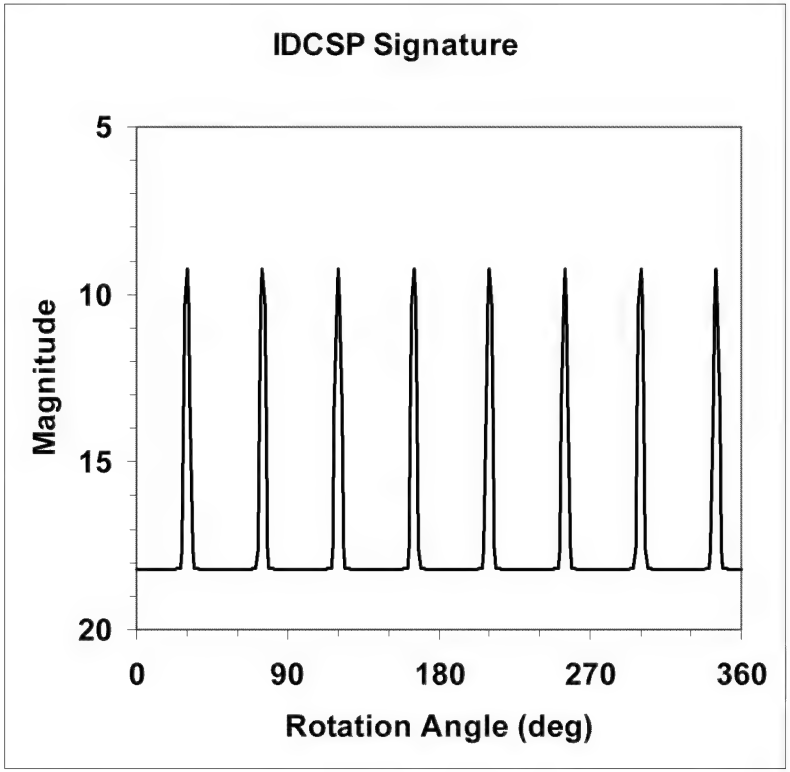
- IDCSPs Below Nominal SSN Optical Sensivity
  - Less Than 1 Meter Diameter
  - Generally Fainter Than 16th Magnitude
- New Sensors Provide Increased Capability
  - NASA/JSC CCD Debris Telescope (CDT): 17 Mv
  - JPL NEAT Camera on MSSS 1.2-m Mount: 20 Mv
  - AF Research Laboratory (AFRL) Raven Telescopes: 16.5 Mv
  - Planned Deep Stare Upgrade for GEODSS: ~18 Mv
- Examine CDT and Raven UCT Detection Data
  - Identify Candidate Objects From Nightly UCT Detections
  - Correlate Night-to-Night Detections To Generate Orbits
  - Target Observations With Sensitive Sensors
- Effort is a "Work in Progress"

Detailed Signature Modeling

- Model Solar Panel Glints
- Utilize Measurement Data
  - Era Production Solar Panel
  - Individual Solar Cell Bi-Directional Reflectances
  - Full Panel Solar Cell Normal Orientations
  - Determination of Satellite Observables Study. SAMSO TR 73-291
- Full Panel Characterized
  - Individual Cells Combined
  - Near Gaussian 1.97° FWHM
  - 0.10 Albedo (CCD Band)
  - 0.1-m^2 IDCSP Solar Panels



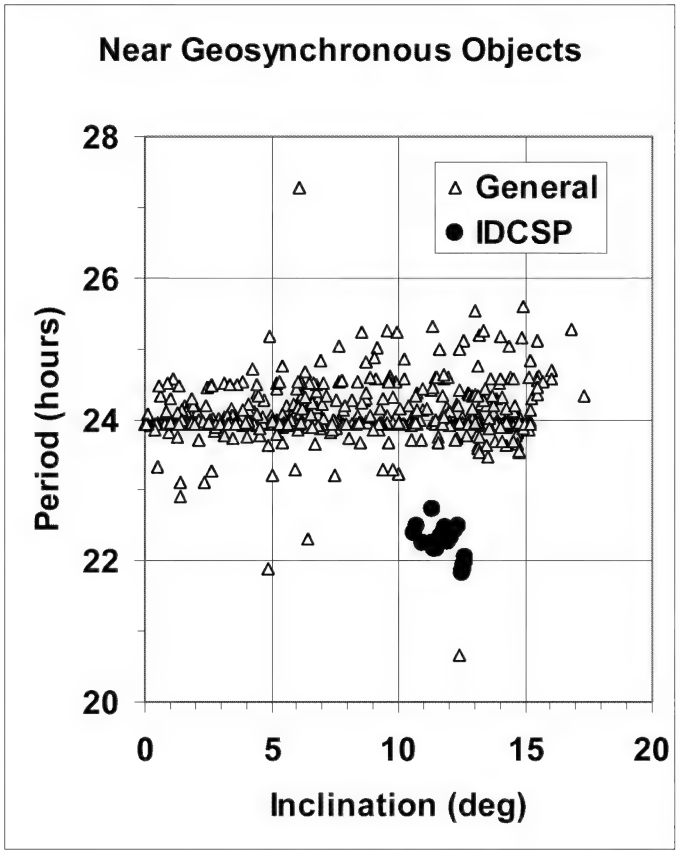
IDCSP Signature Prediction



Modeled Equatorial Glint Sequence

- Signature Characteristics
  - Maximum Glint 9th Magnitude
  - Base Level 18th Magnitude
  - Above 16th mag for 5° Rotation
- Glint Occurrence is Highly Geometry Dependent
  - Monte Carlo Simulations
  - 0 to 8 Glints / Rotation Possible with Decreasing Probability
  - > 50% Cases Observe No Glints
  - Average < 1 Glint per Rotation
- Very Stressing Target !
  - Low Intrinsic Brightness
  - Infrequent, Short Glints
  - Spin Rate Unknown

IDCSPs Are Unique Orbital Group



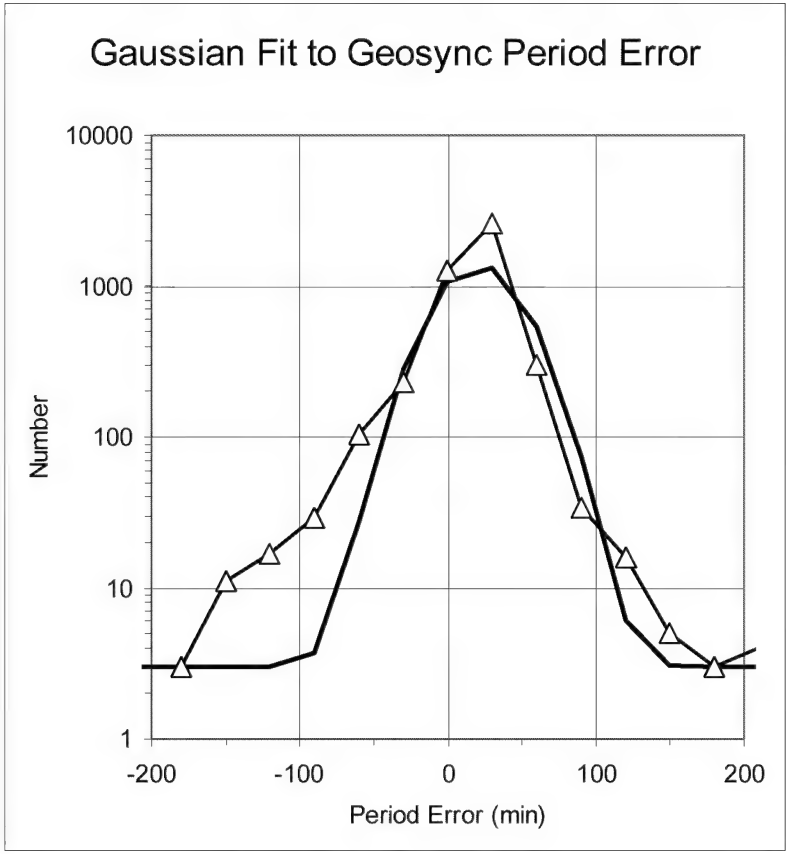
- **Planes Well Characterized**
  - Long Term Perturbations
  - Occasional IDCSP Observations
  - Transtages & Other Payloads
- **IDCSP Orbit Characteristics**
  - Periods: 22.2 ± 0.2 hrs
  - Inclinations: 11.8 ± 0.5 deg
  - RAANs: 347 ± 10 deg (subsets)
- **Search CDT / Raven UCT Data**
  - Search Night-by-Night Detections
  - Identify Correlated Detections
  - Examine UCT Period, Inclination, and RA of Ascending Node
  - Identify High Probability UCT Candidates for Detailed Study

CDT / Raven Detections

- NASA CDT Searches Are Primary Data Source
  - 3 Years of Nightly Geosynchronous Belt Searches
  - Thousands of Correlated and Uncorrelated Detections
- Estimate UCT Orbits from Motion
  - Period And Inclination Computed For All Detections
  - Orbital Determination Accuracies From Correlated Targets
    - Period: 21 +/- 28 minutes
    - Inclination: 0 +/- 3 degrees
  - No Night-to-Night Correlations Performed
- AFRL Raven Data Analysis Underway
  - Processing Similar to CDT
  - Eight Months of Observations From AF Demos Available
  - Operational Raven on Haleakala In Near Future

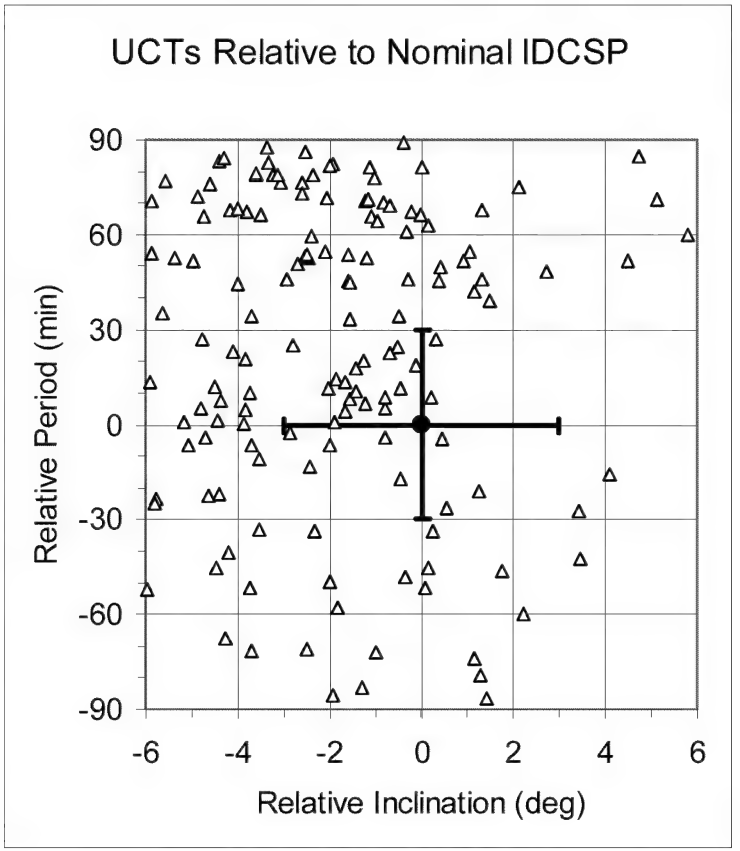
Detection Orbital Accuracy

- **Orbit for Each Detection**
  - Circular Orbit Approximation
  - Short Arcs: 125 sec Median
- **Examine Near-GEO Objects**
  - Correlated CDT Detections
  - Period 0.9 to 1.1 Days
  - Inclinations 0 to 20 Degrees
  - Eccentricities < 0.1
  - 4,634 Detections from '98 & '99
- **Orbital Uncertainties**
  - Period: 21 ± 28 minutes
  - Inclination: 0 ± 3 degrees



Associate UCTs with IDCSPs

- Assign Probability of Being IDCSP to Each UCT
- Intrinsic IDCSP Scatter
  - Average and St. Dev.
  - Period: 1334 ± 12 minutes
  - Inclination: 11.8 ± 0.5 deg
- Observational Uncertainty
  - Bias and St. Dev.
  - Period: 21 ± 28 minutes
  - Inclination: 0 ± 3 degrees
- One Sigma UCT Bounds
  - Period: 1313 ± 30 minutes
  - Inclination: 12 ± 3 degrees



Pursue IDCSP Candidates

- Expect 99.7% of IDCSP Detections Within 3 sigma
  - 166 UCTs Identified for Further Study
  - Some Detections Are Unrelated Objects
- Detailed Analyses Underway
  - Comparing to Expected RA of Ascending Node Distribution
  - Examining Temporal and Spatial Distributions
  - Pursuing Potential Long Term Correlations
  - Associate Individual Detections into Orbits
- Conduct Searches Based on Updated Orbits
  - JPL NEAT Camera on MSSS 1.2-m Mount
  - Phoenix Baker-Nunn with CCD
  - MSSS Raven

MSSS Scheduling IDCSP Observations

- Some Detections Have Correlated to IDCSPs
- Maui Space Surveillance System (MSSS) Is Now Scheduling IDCSP Observations
  - In Addition to Statistical UCT Analysis
  - Using Published Space Command Element Sets
  - Assigned to NEAT Sensor as Available
  - Included in Nightly MSSS Raven Schedule
- Above and Beyond AFSPC Tasking to MSSS
- Report Detections Through Appropriate Channels

Conclusions

- IDCSP Constellation Provides Unique Challenge
  - Family of Known US Spacecraft
  - Distinctive Orbital Characteristics
  - At Limit of Current Capabilities
- Recovery Will Provide Measure of New Sensor Performance

IDCSP RAAN Distribution